

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

**A USER FRIENDLY GEOGRAPHIC INFORMATION SYSTEM
FOR SOIL CONSERVATION PLANNERS**

A Thesis Presented in Partial Fulfilment of the Requirements
for the Degree of Master of Agricultural Science in Soil Science
at Massey University

ENDANG SAVITRI

1994

ABSTRACT

Soil conservation is an important activity for sustainable, productive landuse. To ensure sound effective soil conservation planning, the people who are involved in this activity - the planners and the decision makers - should know (among other things) how best to use a land resource inventory database, which has been stored in a computer.

Using Geographic Information Systems (GIS) to analyse such data is a technique which is being widely advocated. Unfortunately, most GIS computer programs are too difficult for the people like soil conservation planners who usually have little knowledge of computers. To help them understand GIS and then use GIS for their planning, a user friendly interface to the GIS was created.

Two systems were created for the Pijiharjo sub-watershed, Indonesia; one with a **popup** menu, the other with a **pulldown** menu. Both interfaces were created using the SML (Simple Macro Language) command which is available under pc ARC/Info version 3.4D Plus. Although they looked different to the user, both used the same commands to execute the various operations.

Once the initial design was completed, an evaluation was held to check whether the design was satisfactory from the user's point of view. The result of the evaluation showed that both systems were simple and easy to understand.

However, there were some aspects that should be revised, such as the HELP facility.

Similar databases from other areas could be analysed using these interfaces with the only requirement being a modification to the introductory remarks. Ideas for the future development of such systems are also discussed.

ACKNOWLEDGEMENTS

I would like to express my gratitude and appreciation to the following people for their contribution towards the completion of this thesis :

Mr. M.P. Tuohy, for his supervision and suggestions during the course of my study.

Mr. R.G. Gibb, for his supervision, continual guidance, encouragement and valuable suggestions.

Messrs. J.R. Fletcher, M.R. Jessen and other officials in Landcare Research Ltd. Aokautere New Zealand, for their friendship.

Mr. L.J. Brown and Mrs. S.D. Hendriksen, for their comments, suggestions and friendship.

All of the people who evaluated my systems, for their comments and suggestions.

The New Zealand Ministry of Foreign Affairs and Overseas Trade, for the scholarship grant and the Ministry of Forestry of Indonesia, for granting study leave.

All Indonesian friends at Massey University.

My parents and sister, for their encouragement and continual prayers.

TABLE OF CONTENTS

ABSTRACT	i
ACKNOWLEDGEMENT	iii
TABLE OF CONTENTS	iv
LIST OF FIGURES	viii
LIST OF TABLES	ix
LIST OF APPENDICES	x

CHAPTER I

INTRODUCTION

Background of Study	1
The Study Area	3
Existing data	5

CHAPTER II

OVERVIEW OF GEOGRAPHIC INFORMATION SYSTEMS

Introduction	10
Applications of GIS	13

The Users	16
Reasons for Developing the Interface	20

CHAPTER III

COMPARISON BETWEEN ARCVIEW AND A PURPOSE-DESIGNED

USER INTERFACE

Overview of ARCVIEW	23
<i>Introduction</i>	23
What is a View	24
<i>ARCVIEW Capability</i>	24
Display	24
<i>ARCVIEW Weaknesses</i>	25
The Purpose-designed User Interface	26
<i>User Interface Capabilities</i>	27
DISPLAY	27
ANALYZE	27
OVERLAY	28
PLOT	29
Discussion	29

CHAPTER IV

DESIGNING USER INTERFACES

Overview of User Interfaces	34
<i>The Users</i>	35
<i>The Design Principles</i>	37
Purpose-designed User Interfaces	39
<i>Popup Interface</i>	39
<i>Pulldown Interface</i>	40
Discussion	41
<i>Simplicity</i>	41
<i>Consistency</i>	42
<i>Efficiency</i>	46

CHAPTER V

THE EVALUATION

Introduction	49
<i>The Objective</i>	50
<i>The Criteria</i>	52
The Methods	57
Results and Discussion	60

CHAPTER VI

THE APPLICATION

Introduction	63
Completing the Task Using pc ARC/Info	65
Completing the Task Using the Purpose-designed	
Interface	70
Discussion	78

CHAPTER VII

CONCLUSION AND FUTURE DEVELOPMENT

Conclusion	80
Future Development	82
REFERENCES	85

LIST OF FIGURES

Figure 1.	Location of the Study Area	4
Figure 2.	The Popup Main Menu	40
Figure 3.	The Pulldown Main Menu	41
Figure 4.	The Pulldown ANALYZE Menu	43
Figure 5.	The Pulldown OVERLAY Menu	43
Figure 6a.	The Popup DISPLAY Menu	44
Figure 6b.	The Popup Terrace Sub-menu	45
Figure 7.	The Popup ANALYZE Menu	45
Figure 8.	The Popup UPDATE Menu	47
Figure 9.	The Pulldown UPDATE Menu	47
Figure 10.	Final Map Created Using PC ARC/Info Directly	69
Figure 11a.	Map Produced Using the Purpose-designed Interface - 'The Unterraced Areas'	74
Figure 11b.	Map Produced Using the Purpose-designed Interface - 'Terrace Construction'	75
Figure 11c.	Map Produced Using the Purpose-designed Interface - 'Agro-forestry Development'	76
Figure 11d.	Map Produced Using the Purpose-designed Interface - 'Forestry System'	77

LIST OF TABLES

Table 1.	Land Resource Inventory Items as Stored in IRIS	7
Table 2.	Items from IRIS that Have Been Expanded	8
Table 3.	User Groups and Their Demands (Scholten and Stillwell, 1990)	17
Table 4.	Decision Making Levels in Soil Conservation with Associated Agencies, Tasks, Measures, and Tools	18
Table 5.	Comparison between ARCVIEW and the Purpose-designed User Interface	30
Table 6.	A Comparison of the Criteria in Evaluating an Interface Proposed by Shneiderman (1992), Lea (1988) and Ravden and Johnson (1989)	54
Table 7.	Items Contained in the Pijiharjo Database	65
Table 8.	Commands Used for Plotting the Map	68
Table 9.	Comparison Between ARC/Info Commands and the Purpose- designed Interface Complete with Explanations	71

LIST OF APPENDICES

Appendix 1. The Questionnaire	90
Appendix 2. The Application Tasks	102
Appendix 3. The Purpose-designed User Interface User Manual	109
Appendix 4. Abbreviations and Class Descriptions Used in the Database ..	129

CHAPTER I

INTRODUCTION

Background of Study

Soil erosion is a common problem in tropical countries, where rainfall, as the most erosive factor, is abundant. The loss of soil and subsequent land degradation often results in a reduction of farmers' incomes. To improve this situation, action must be taken to conserve the soil and manage the land in a more sustainable way.

Soil conservation can include a variety of activities by humans to control the rate of degradation, loss of soil and yield of sediment from the landscape (Perrens and Trustrum, 1984). These activities may be categorized into two major groups, biological control and mechanical control. Biological control activities attempt to conserve the land naturally, by tree planting, multiple cropping, or conservation tillage. Mechanical control, on the other hand, generally involves building dams, drop structures, or terraces.

Perrens and Trustrum (1984) also discuss two levels for making soil conservation decisions; policy making and planning. At the policy making level, the scope is broad, influencing the national and regional land and water management options.

At the planning level the scope is more limited and consequently more detailed. Planners must have a thorough understanding of the land and water resource before recommending any regional management.

Unfortunately, in developing countries decision making for soil conservation purposes is not simple. Problems arise when planners start to collect the data. Socio-economic data which are essential for planning are usually unavailable. If they are available, planners often neglect them, because it is difficult to combine land resource data and socio economic data which may relate to areas which do not have similar boundaries.

Institutional coordination is another problem. Soil conservation policy may involve many agencies, including forestry, planning and irrigation, which are not in the same department. They often have their own data, design their own planning and execute it according to their own schedule. For the farmers who own and manage the land, this situation can cause confusion. They are confused by the many activities which are sometimes similar, but conducted by different agencies. This may lead to a reluctance to implement soil conservation practices.

Ventura *et al.* (1988) suggest that the use of a Geographic Information System (GIS) for soil conservation planning could solve the institutional coordination problem. Automation could be used as an opportunity for agencies to coordinate their data collection and to eliminate duplication or redundancy.

By implementing GIS for soil conservation planning, it is assumed the decision makers and the planners understand the system. They need to know how to extract information for their particular application. Unfortunately most GIS's are not that easy to understand. This could mean that the users, in this case the decision makers and the planners, must be trained to operate GIS before they can use it effectively. Another way to help the planners and decision makers use the data is to make the GIS easier to use. Complicated instructions could be kept disguised behind tailor-made programs designed specifically for the non GIS specialist. A user-friendly interface or tailor-made program could make the GIS much more accessible.

The objectives of this study are :

- to demonstrate the use of GIS for soil conservation planning using already-available data
- to design a user interface for the policy makers and planners

The Study Area

The study area is located in Pijiharjo sub-watershed, Upper Solo watershed, Central Java, Indonesia, and occupies an area of about 533 ha (Figure 1). It is mainly flat with some rolling low hill country, mostly bench-terraced, which supports crops such as dry-land paddy, maize, cassava, and peanuts (Jessen, 1992).

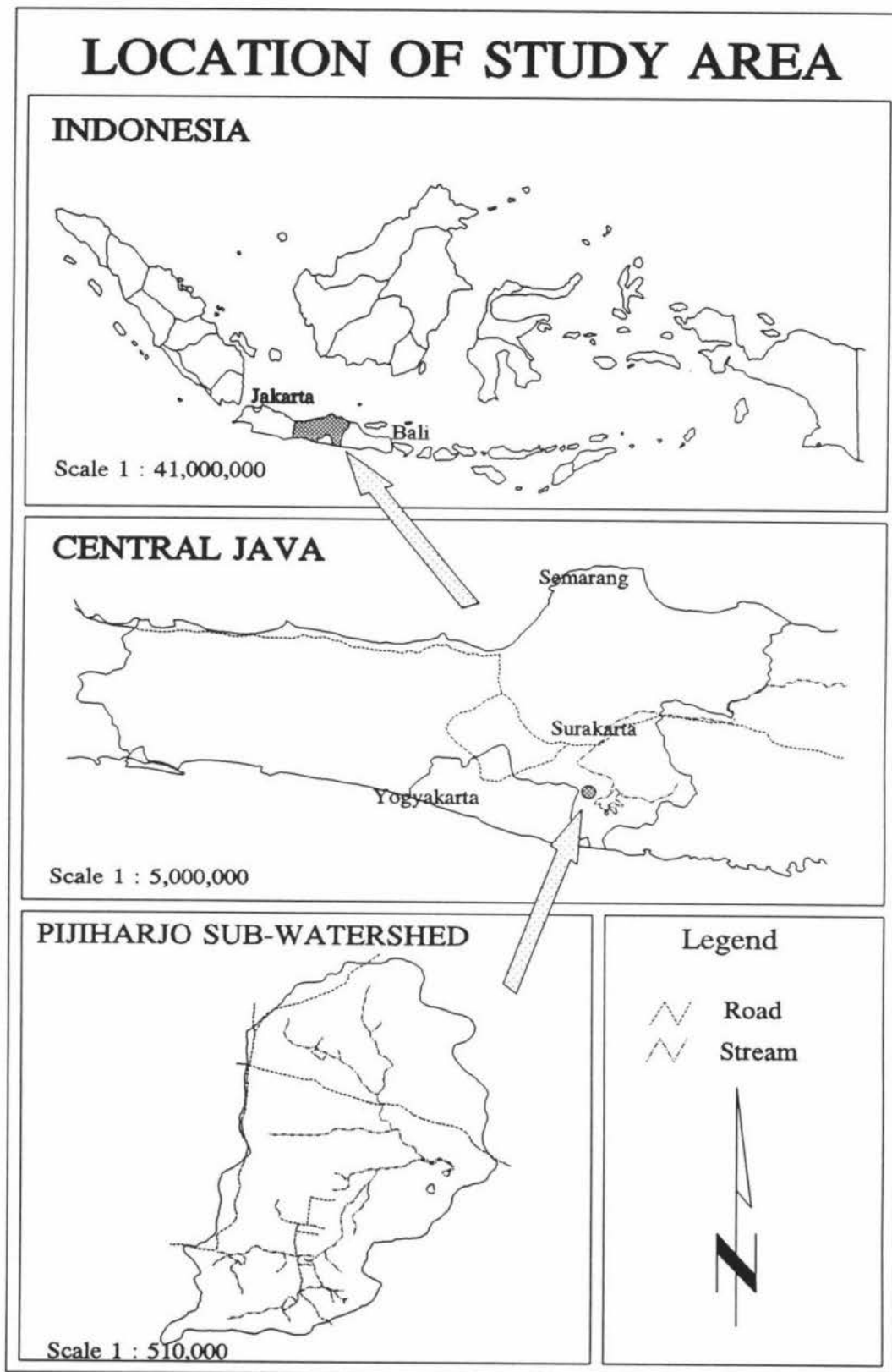


Figure 1. Location of the Study Area

Pijiharjo is part of the region which constitutes the Indonesia-New Zealand Project. The objective of this project is to train the planning staff of the Watershed Management Technology Centre (WMTC) Solo - which is under the Ministry of Forestry (MOF) - and to collect the land resource inventory data for soil conservation planning (Fletcher and Gibb, 1990).

Fletcher and Gibb (1990) introduced a simple and useful inventory system, called IRIS (Indonesian Resource Inventory System). It involved multi-factor mapping within homogeneous map units, recognised on the basis of their land management requirements for long term sustained use. One advantage of this system is that the data can be joined with other resource information such as socio economic data or environmental data.

Existing data

The Pijiharjo inventory survey was completed in 1991 by WMTC - Solo staff. The objectives of the survey were (Jessen, 1992) :

- to test the suitability (and applicability) of IRIS at an intensive mapping scale (1 : 5000).
- to enhance opportunities for improving the sustainable landuse of the Pijiharjo sub watershed by using integrated watershed management planning.

- to make a contribution to the knowledge of land resources in the Upper Solo watershed.
- to train MOF staff in land resource mapping.

Jessen (1992) developed the IRIS survey data using multi-factor mapping of landform, slope, rock, soil, erosion, soil conservation measures and land cover/use factors within homogeneous map units. The result was a 1 : 7500 scale presentation based on a 1 : 5000 reference map with a database of 386 map units which were grouped into 19 landuse capability (LUC) units. A full list of items stored in the land resource inventory database is given in Table 1.

The resource inventory data were originally stored and manipulated using the interface called ARC/Manager. ARC/Manager was designed specifically to help arrange the data, from entering the field data to producing maps, based on PC ARC/INFO commands. It was hoped, that by following the steps in ARC/Manager, good data management could be achieved and a high degree of data integrity assured. More details of this interface can be found in Gibb (1990).

To enable more detailed analysis it was necessary to further subdivide the items which carried the information on terracing, LUC units, erosion and land-cover.

Table 1. Land Resource Inventory Items as stored in IRIS

COLUMN	ITEM	DESCRIPTION
1	Area	} Items built
14	Perimeter	} by PC
27	ICLM_	} ARC/INFO
38	ICLM_ID	}
49	LF	Landform
55	RO	Rock type
63	RD	Regolith depth
64	SL	Slope
67	ER	Erosion
76	SDL	Soil depletion
77	TE	Terrace
82	LU	Land-cover
94	SO	Soil
102	SD	Soil depth
103	BR	Bare rock
104	LUC	Landuse Capability
110	MU	Map unit
121	HA	Area in HA
134	Percentage	% of total

The terrace inventory included four types of information; intensity of terracing, type of terrace, percentage of terrace risers that are vegetated and terrace condition. For example, if the terrace data is '6Br2m', it means that the intensity of terracing is 6 (more than 80% terraced), the terrace type is Br (Bench Reverse), terrace risers are vegetated to level 2 (20 - 50%), and the terrace condition is m (moderate).

Like the terrace inventory factor, the Land Use Capability (LUC) item is divided into three subitems, class, sub class and unit. If the LUC data is 'VIIs1', it means that the class is VII, the subclass is s (soil limitation), and the unit is 1.

Erosion data, was also encoded in a complicated way. The erosion inventory item contained three kinds of data; erosion severity, erosion type and erosion extent. If the erosion data code is '1S 4 1G 1', this means that two kinds of erosion occur in one map unit, the first of which is dominant. For the dominant type, the erosion severity is 1 (slight erosion); the erosion type is 'S' (Sheet erosion); and the erosion extent is 4 (40 - 60% of the area is eroded). The minor type has an erosion severity of 1 (slight erosion); an erosion type of 'G' (Gully erosion); and an erosion extent of 1 (1 - 10% of the area is eroded). Table 2 presents the expanded items. The user interface, then, was designed with these modifications. Further details of the database can be seen in Jessen (1992).

Table 2. Items from IRIS that Have Been Expanded

Old Item (width, type, n.dec)	New Items (width, type, n.dec)	Description
TE (5, C, 0)	Intte (1, N, 0)	Intensity of terracing
	Typte (3, C, 0)	Type of terrace
	Riste (1, N, 0)	% risers vegetated
	Conte (1, C, 0)	Terrace condition
LUC (6, C, 0)	Class (1, N, 0)	Class
	Sub (1, C, 0)	Subclass
	Unit (1, N, 0)	Unit

Old Item (width, type, n.dec)	New Items (width, type, n.dec)	Description
ER (9, C, 0)	<u>Dominant :</u>	
	Sever1 (1, N, 0)	Erosion severity
	Typ1 (2, C, 0)	Erosion type
	Exter1 (1, N, 0)	Erosion extent
	<u>Minor :</u>	
	Sever2 (1, N, 0)	Erosion severity
	Typ2 (2, C, 0)	Erosion type
	Exter2 (1, N, 0)	Erosion extent
LU (12, C, 0)	LU1 (4, C, 0)	Dominant land-cover
	LU2 (4, C, 0)	Second dominant
	LU3 (4, C, 0)	Minor land-cover